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Using Random Sampling to Estimate Insect Counts as Response Surfaces Involving Space and Time

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ABSTRACT

In fall 2000, an on-farm sustainable agricultural research project was established for cotton (*Gossypium hirsutum* L.) in Tift County, Georgia. Twenty fields that were to be planted to cotton in 2001 were identified which were approximately 5 to 10 acres in size. Four randomly selected fields were assigned to each of five cover crops: 1) cereal rye (*Secale cereale* L.); 2) crimson clover (*Trifolium incarnatum* L.); 3) legume mixture of balansa clover (*T. michelianum* Savi), crimson clover, and hairy vetch (*Vicia villosa* Roth); 4) previous legume mixture plus cereal rye; and 5) no cover crop (fallow) in conventionally tilled fields. Cotton was planted in two rows (36 in apart) on six foot beds. A strip was burned out in each row in the four cover treatments using paraquat so cotton could be planted. In the spring, insect counts were determined using sweep nets in the covers and when the cotton was small. Cotton plants from emergence to four weeks old were not sampled since the sweep net could break the fragile cotton plants. Five more weeks of sweep net data were collected from cotton. Insect samples after this involved whole plants since the cotton was too big for the sweep net to be effective. Each field was divided into 24 x 24 foot sample areas beginning at the center of the field. Each week for 14 or 15 weeks, 21 samples were obtained from each field. Comprising the 21 random samples were one sample from the four center plots, one sample from each of the four sides, and four samples from each of the four quadrants. Thus throughout the season, a five acre field could have most of the plots sampled at least once. Larger fields saw a smaller percentage of all the plots sampled. No interior plot excluding the center and edges was sampled a second time until every plot had been sampled once. A response surface was fitted for the weekly data for each field. As would be expected, high densities of insects resulted in a significant fit.

1. INTRODUCTION

One of the most dynamic species to sample for is insects. They are ubiquitous in that they occur on every known plant species, whether grown for food or fiber, or classified as a garden flower, wildflower, or weed. Numerous species of insects are found on cotton (*Gossypium hirsutum* L.) and are classified either as a pest, parasitoid, or predator (Tillman et al., 2004). Pests include these Heliothines: The TBW (tobacco bud worm), *Heliothis virescens* (F.), and CEW (corn ear worm), *Helicoverpa zea* (Boddie). Other pests include the TPB (tarnished plant bug), *Lygus lineolaris* (Palisot de Beauvois), SGSB (southern green stink bug), *Nezara viridula*, BSB (brown stink bug), *Euschistus servus* (Say), and GSB (green stink bug), *Acrosternum hilare* (Say). Parasitoid insects parasitize pest insects, but do not bother the cotton otherwise. Predatory insects feed on other insects. Some feed primarily on insects. Others feed on the cotton plant as well. These include the big-eyed bug, *Geocoris punctipes* (Say); pirate bug, *Orius insidiosus* (Say); red imported fire ant, *Solenopsis invicta* Buren; and four lady bugs: convergent lady beetle, *Hippodamia convergens* Guerin-Meneville; seven-spotted lady beetle, *Coccinella septempunctata* L.; ladybird beetle, *Coleomegilla maculata* (DeGeer); and multicolored Asian lady beetle, *Harmonia axyridis* (Pallas).

Cotton is grown primarily for the cotton fiber that is produced by the seed. During the last half of the 20-th century, pressing cotton seed for cotton seed oil became an international business (all vegetable oils now rank among the ten most traded commodities on the world market) (Cherry et al., 1986). The pulp that is left after pressing is often fed to cattle as well as other livestock. However, whole cottonseed is also fed to cattle. Cattle will consume the cotton

stalks left after machine picking and will even eat the cotton bolls that are lost during harvesting. Cotton is a multi-billion dollar industry in the United States. It is an even bigger industry outside the U.S.

Cotton is a tropical plant that dies when the air temperature drops below 32 degrees F (0 C) for any appreciable length of time (Mauney, 1986). Across the southern portion of the U.S., cotton is generally planted in May or early June and is prepared for harvest in September or October by spraying a herbicide-like chemical that causes the leaves to drop off the plant (Delouche, 1986). Cotton is harvested by spindle pickers in the southeast and in Arizona and California, while it is harvested by stripper pickers in Texas. Some stripper pickers are used in the Mississippi Delta region to recover the cotton left on the plant after the first pass with a spindle picker. Cotton which is stained by the green leaves is docked heavily at the cotton gin since it requires bleaching to restore its whiteness. Colored cotton is native to Peru, Bolivia, and northern Chile (Cherry et al., 1986). The high plains region of western Texas, the first killing frost of the season is generally used to kill the plant and this causes the leaves to drop off.

Over half of all the cotton grown in this country is irrigated (including that grown in Georgia, Texas, Arizona, and California). This makes the cotton plant more attractive to the insects that have learned to feed on the various parts of the cotton plant. Since the cotton boll is the most desired part of the plant from the standpoint of value to the grower, a lot of money is spent to keep insects off the boll. However, the current market price for cotton is around forty cents per pound of lint cotton (the fiber removed from the seed during ginning). This makes it increasingly unreasonable to apply expensive chemicals to the bolls to keep the insects from attacking the boll while it is developing. Research at Tifton has demonstrated that under typical

conditions the boll requires approximately 49 days from bloom until it is ready for harvest during the hot summer (Bednarz, personal communication). Cooler conditions lengthen the time for development. In an effort to reduce chemical pesticide usage, various cover crops were proposed as a means of attracting predatory insects of cotton before the cotton is planted, hoping they would remain nearby so as to attack the insect pests of cotton when they arrive. A sustainable agriculture grant was proposed and was funded as part of a larger grant proposal to be administered on-farm in hopes of demonstrating an alternative to chemical pesticide use (these grants also support organic farming).

2. METHODS AND MATERIALS

A detailed description of the experiment can be found in Tillman et al. (2004). Each field was drawn to scale from the Tift County Soil Survey. All rectangular fields were divided into four quadrants. Distances were measured to establish the size of each field to determine how many 24x24 foot sampling areas there were. The paper map was then completed to reflect the total number of 24x24 foot sampling areas. In each quadrant the four center plots were marked off first and labeled (1-4). The four edges of each quadrant were then marked off and numbered beginning from right side for the bottom edge or upper right corner for the right edge, and from the left side for the top edge or lower left corner for the left edge. The remaining plots were numbered beginning at the corner opposite the center and proceeded row by row. Irregular fields were marked off in quadrants as best as could be done. Using a backpack GPS unit, coordinates were established for each quadrant in each field. An algorithm was developed to assign

coordinates to each plot. A beeper on the GPS unit would signal when the correct plot was found. A sweep net was used to catch the insects present on the plants. The insects were killed with CO₂ gas and placed in a sampling container for later identification in the laboratory. This procedure was repeated for every plot that had been randomly selected to be sampled each week.

A SAS (SAS, 2002) program using Proc PLAN was constructed to provide the randomly selected plots that were to be sampled each week in each field (Cochran and Cox, 1957). One of the four center plots were selected each week for each field to be sampled. One plot from each of the four edges was randomly selected each week for each field to be sampled. Four to 14 plots were randomly selected from each quadrant each week for each field to be sampled. The number of plots sampled for each field varied from 21 to 61 depending on the number of student workers available and on time constraints. All twenty fields' randomly chosen numbers were entered in to a special file format to operate in backpack GPS unit that was plugged into a laptop PC. Out in the field, the two people assigned would follow a map showing where the plots to be sampled this week were located. The GPS unit would beep when the 24 x 24 foot plot's center was found. This was possible since the GPS coordinates for a corner of the field was loaded into the PC and each plot's center was automatically determined. The data were entered into a PC in an Excel worksheet. The worksheet's contents were read directly into the SAS analysis program using the dde (dynamic data exchange) feature in the data step of SAS. Once the data was brought into SAS, the data were sorted and merged with a master file that contained every plot that could have been sampled for every field for every week. After merging and then by sorting by cover crop and sampling week, Proc MIXED (SAS,2002) was used to analyze the data to fit a response surface model that described the mean of the four fields with the same cover crop treatment. The

model used the following fixed effects: tLRdistance (distance left to right in units of 24 feet where the first plot either left or right of the center had a value twelve, the values were divided by 10, values to the left were negative); tUDdistance (distance up [north] to down in units of 24 feet where the first plot either above or below of the center had a value twelve, the values were divided by 10, values to the below were negative); tLRdistance*tLRdistance; tUDdistance*tUDdistance; and tLRdistance*tUDdistance. The model statement option 'OUTP=data-set-name' was used to create an output file with the predicted values for every plot in every field. This new output file was divided into the five cover crop treatments and two sampling week groups: 1) when the cover crops were present (weeks 1-10), and 2) when the cotton was present (weeks 14-18). A second Proc MIXED analysis was used to analyze the data. The model used the following effects: mSampleWeek (either weeks 1-10 with 5.5 subtracted from each week value [suggested by Draper & Smith, 1981] for the cover weeks; or weeks 14-18 with 16 subtracted from each week value for the cotton weeks); mSampleWeek*mSampleWeek; tLRdistance (as described previously); tLRdistance*tLRdistance; tUDdistance (as described previously); tUDdistance*tUDdistance; mSampleWeek*tLRdistance; SampleWeek*tUDdistance; and tLRdistance*tUDdistance. The solution betas were used in a third SAS program to construct the three dimensional set of data comprised of sample week, left-right distance, and up-down distance. Proc G3D was used to construct response surfaces depicting the values associated with these three analysis variables (Total Insect Pests [destroy cotton plant], Total Insect Predators [attacks insect pests], and Total Insect Parasitoids [attack the Heliothines {worms}]) on a weekly basis (195 of these graphs were produced). Two graphs were placed on a landscaped page which resulted in 105 landscaped pages. Results for Crimson

Clover cover crop will be presented.

3. RESULTS AND DISCUSSION

Two examples will be presented. Figure 1 shows the shape of Branch's field where the cover crop Blend+Rye was planted. The four center plots were labeled A-D. The edges were numbered as well. Notice how the interior plots were numbered beginning with the four corners and proceeding towards the center. Table 1 contains the SAS statements used produce these random plot numbers for Branch's Blend+Rye. The first factors request is to get the center plot to sample each week. The next four factors requests are to get one plot from the edge plots for each week. The remaining eight factors requests are to get 13 plots each week from two of the larger quadrants, while 11 plots each week from the two smaller quadrants. It takes about 12 weeks to sample every plot once from the larger quadrants, while it takes about 13 weeks to sample every plot from the smaller quadrants.

Table 3 shows the results of the analysis of the data collected that was classified as Total Insect Pests (data are the predicted values computed for each 24 x 24 foot plot area in every field) before cotton is planted. The analysis performed by Proc MIXED (SAS, 2002) is divided into two parts, random and fixed effects designated as either R or F, respectively. Variances for random effects are components of variance and are present if the contribution to variance exceeds the total variance associated with all random effects below it (Residual is an exception). A multiplier is associated with each variance component, except for Residual Error which has a multiplier of one. Although the five cover crop treatments had a non-zero and non-negative

value, its contribution is not as important. Variance components for DLR(CC) [read DLR within Cover crop] and DUD(CC) are for the unused SS and DF left after fitting the fixed effects for DLR linear and quadratic and for DUD linear and quadratic which are significant contributions to variance. Sample Week had a variance component of zero which means that the portion left over after fitting the fixed effects of linear and quadratic was not large enough. The interaction of CC and Sample Week as a variance component had a significant contribution to variance. It was not expected that there would be a linear effect due to Sample Week since insects in general are known for increasing population numbers when the crop is attractive and then decreasing when the attractiveness subsides. The quadratic effect due to Sample Week is extremely significant (F ge 126.62). Linear and quadratic effects of DLR was significant, but only the linear effect of DUD was significant. Only the interaction of linear effect of Sample Week with the linear effect of DUD was highly significant (F ge 133.76). The interaction of linear effect of DLR with the linear effect of DUD was highly significant (F ge 193.40). The three way interaction of the linear effects of DLR, DUD, and Sample Week was significant. Table 4 shows the results of the Proc MIXED analysis of the predicted data from the twenty fields after cotton had been planted. The big surprise was the pronounced linear trend associated with Sample Week. However, there was no three way interaction. Table 5 shows the results of the Proc MIXED analysis of the predicted data from the twenty fields before cotton is planted for Total Insect Predators. The analysis is similar to Total Insect Pests which is the reason for the cover crops originally. This was certainly gratifying to see that the predators showed up because the insect pests were there. It is suspected that the attractiveness of the cover crops is what brought both pests and predators since there is a substantial amount of food present. Table 6 shows the

results of the Proc MIXED analysis of the predicted data from the twenty fields after cotton had been planted. The biggest surprises were the presence of a linear trend associated with Sample Week and the amount of interaction of linear Sample Week with both DLR and DUD. However, there was no significant three way interaction. Table 7 shows the results of the Proc MIXED analysis of the predicted data from the twenty fields before cotton is planted for Total Insect Parasitoids. The analysis is similar to Total Insect Pests which is the reason for the cover crops originally. This was certainly gratifying to see that the parasitoids showed up because the insect pests were there, especially TBW and CEW. Table 8 shows the results of the Proc MIXED analysis of the predicted data from the twenty fields after cotton had been planted. The big surprise was the amount of interaction of linear Sample Week with both DLR and DUD. There was a significant three way interaction.

Figure 2a-e show the results of the weekly sampling transformed using a response surface methodology as described in Cochran and Cox (1957). Crimson clover produces a head of crimson colored tiny blooms arrayed in a bell shape. Insects love the plentiful supply of nectar and pollen available. There are tens of thousands of these plants in an acre. Cotton insect pest counts were near zero at week 1, but began to climb steadily towards week 5 where surface lies near a value of 14. This level is maintained through week 7. The level begins to decline towards zero by week 10. Cotton is planted at about this time. Weekly sampling resumes at week 14 when the cotton is sturdy enough (about 21 after germination) to withstand the sweep net used to collect the insects. Insect pests appear to be the most numerous during week 14 (Figure 3a-c) when the plant is rapidly growing and plenty of food is traveling back and forth between the leaves and stems and the roots.

The purpose of the research is to determine if the insect predators are following the cotton insect pests into the cotton fields. Figure 4a-e shows the level of insect predators from week 1 through week 10. The greatest numbers occur during weeks 4 through 8, at count of approximately six per plot. This demonstrates that the peak count occurred at the same time as the peak count of the insect pests. This was the hypothesized value of the various cover crops. After the cotton was up and growing, the number of insect predators was above three per plot for all five weeks of sweep net sampling (Figure 5a-c). Two of the insect pests are members of the Heliothine family: TBW (tobacco bud worm) and CEW (corn ear worm).

A parasitoid is small wasp that punctures their host and deposits an egg inside of it. Parasitoids attack Heliothine worms. Figure 6a-e depict the levels of parasitized worms found in the sweep net samples. Their numbers peaked during weeks 4 through 6 which is the same time that these two insect pests were found. They were present as well during the sampling of the young, growing cotton plants during weeks 14 to 18, but not in as great of numbers.

4. CONCLUSIONS

The data originally analyzed for presentation at a meeting of various groups with SARE grants seemed to indicate that the insect predators seemed to lag at least a week behind the insect pests (Tillman, personal communication). However, after obtaining the predicted values from the Proc MIXED analysis of each field's data and putting these predicted values together for a large analysis, graphical representations of the insect pest and predator data began to show that they arrived at nearly the same time as the cover crops. This was justification enough for the amount of work put into sampling so many fields for all those weeks. The graphs did show that there

seemed to be more activity along the edges of the fields than previously believed. Hence, a new grant proposal has been submitted for sampling fewer fields but still studying cover crops. Other field work since has shown that the choice of crop planted adjacent or close to cotton has a huge impact on the numbers of insects found in cotton.

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Figure 1. A drawing showing the shape of Branch's field where the cover crop, Blend+Rye, was planted with the 24 x 24 ft plots numbered.

Table 1. SAS program statements used to produced the needed random numbers to do weekly sampling at the Branch's Blend+Rye Field.

```

title 'G.Tillman 2002: Sampling Plan';

title 'For 20 Cotton Fields with 16 Weeks of Plant Samples';

title 'File: CoverCrop2001';

proc plan; title2 'Field: Branchs Blend+Rye (B+R 01)';

    title3 'Use 1 Number/Week';

    factors Week=16 ordered PlotC=1 of 4; * Center;

    factors Week=16 ordered PlotS=1 of 26; * S edge;

    factors Week=16 ordered PlotW=1 of 25; * W edge;

    factors Week=16 ordered PlotN=1 of 26; * N edge;

    factors Week=16 ordered PlotE=1 of 25; * E edge;

proc plan; title3 'Use 13 Numbers/Week';

    factors Plot=130 of 155; * NW quadrant;

    factors Plot=78 of 155; * NW quadrant;

    factors Plot=130 of 155; * NE quadrant;

    factors Plot=78 of 155; * NE quadrant;

proc plan; title3 'Use 11 Numbers/Week';

    factors Plot=110 of 142; * SW quadrant;

    factors Plot=66 of 142; * SW quadrant;

    factors Plot=110 of 142; * SE quadrant;

    factors Plot=66 of 142; * SE quadrant;

run;

```

Table 2. Output from the SAS program statements in Table 1 showing the random numbers to do weekly sampling at the Branch's Blend+Rye Field.

File: CoverCrop2001					
Field: Branchs Blend+Rye (B+R 01)					
Use 1 Number/Week					
The PLAN Procedure					
Factor	Levels	Order	Levels	Order	Levels
Week	14 O	15 O	16 O	17 O	18 O
PlotC	4 R	26 R	26 R	26 R	26 R
Week	-PlotC-	-PlotS-	-PlotW-	-PlotN-	-PlotE-
1	3	10	21	2	1
2	1	14	8	1	10
3	4	15	16	13	9
4	1	1	12	4	14
5	3	4	3	5	23
6	3	7	11	10	11
7	1	26	13	22	13
8	3	6	16	16	21
9	1	2	11	13	14
10	4	17	7	16	24
11	2	25	16	1	7
12	4	6	20	15	2
13	3	20	25	2	6
14	3	20	22	5	13
15	2	8	21	12	14
16	1	16	2	5	11

Table 2 (continued)

The PLAN Procedure

Factor

Select

Levels

Order

Plot

130

155

Random

49 8 45 137 134 122 29 64 149 143 153 119 144 102 136 117 33 69 104

35 1 89 147 80 11 34 93 70 151 105 139 113 66 127 132 86 101 146

85 81 110 22 124 145 78 21 44 125 67 2 42 88 9 154 63 129 83

103 111 116 97 15 141 75 107 133 100 91 46 40 76 99 24 114 96 68

58 27 25 130 138 43 26 120 135 84 140 118 59 73 10 115 4 30 39

62 155 72 5 14 94 51 150 71 23 77 20 31 48 36 98 50 37 92

12 109 142 19 65 17 79 87 112 126 3 128 82 148 16 13

The PLAN Procedure

Factor

Select

Levels

Order

Plot

78

155

Random

9 138 88 72 114 74 59 14 132 15 4 49 66 120 21 57 64 42 12

69 100 7 106 38 13 135 58 150 39 2 61 96 10 154 26 141 145 83

147 122 84 118 134 137 53 119 82 140 45 153 127 11 149 50 125 142 129

54 116 35 94 18 87 1 89 55 43 123 115 97 79 86 128 37 124 126 20 8

The PLAN Procedure

Factor

Select

Levels

Order

Plot

130

155

Random

116 87 114 90 86 148 81 107 72 70 149 109 137 130 20 97 147 155 22

52 150 113 79 45 129 64 67 48 84 153 110 43 143 123 71 2 115 18

103 140 117 112 21 54 40 88 145 78 126 25 146 63 106 38 34 26 28

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Table 2 (continued)

68 102 74 131 111 91 89 59 139 53 141 19 95 104 4 49 14 105 122
 56 8 44 41 98 100 118 46 10 23 7 69 132 136 29 120 76 17 65
 96 55 11 94 47 119 151 15 30 85 154 36 42 144 125 13 37 121 124
 135 31 33 73 62 80 35 128 9 134 24 12 82 32 142 66

The PLAN Procedure

Factor	Select	Levels	Order
Plot	78	155	Random

140 94 73 54 36 28 43 142 34 117 74 65 11 127 110 13 131 101 152
 154 66 134 37 19 24 56 8 18 15 77 132 76 138 144 96 35 21 109
 104 22 61 80 53 145 9 113 155 20 27 86 116 48 136 124 128 4 146
 106 148 88 147 153 79 50 6 1 5 83 87 135 10 38 26 57 107 133 108 23

The PLAN Procedure

Factor	Select	Levels	Order
Plot	110	142	Random

23 113 119 36 78 57 75 118 85 73 124 107 31 58 91 109 27 41 60
 11 87 44 4 10 77 103 115 100 142 13 39 72 131 21 64 70 127 61
 111 49 133 16 62 123 132 25 125 138 51 94 110 50 81 29 1 45 76
 71 3 139 80 14 137 17 101 12 28 46 129 104 53 134 74 97 2 121
 122 34 32 82 19 5 9 86 96 59 90 42 7 79 48 35 67 38 8
 66 6 89 126 18 112 40 83 99 37 120 30 130 136 102

The PLAN Procedure

Factor	Select	Levels	Order
--------	--------	--------	-------

Table 2 (continued)

Plot	66	142	Random
118 102 57 16 88 83 14 85 97 133 95 58 22 47 122 135 121 129 112			
42 105 56 134 124 106 52 54 51 3 37 77 130 132 13 41 31 2 109			
27 20 113 114 94 1 126 131 63 139 33 34 5 141 19 136 43 12 48			
62 128 36 71 8 104 32 66 116			

The PLAN Procedure

Factor	Select	Levels	Order
Plot	110	142	Random
89 103 130 136 46 115 4 92 17 132 33 75 39 76 81 45 56 117 70			
124 26 14 48 51 40 114 87 30 10 122 11 110 119 7 79 113 73 15			
12 38 20 23 3 67 123 54 85 1 69 72 60 95 116 47 27 127 112			
63 107 126 59 111 29 16 68 31 97 105 2 44 93 140 43 125 106 50			
22 13 94 57 21 91 19 139 55 129 53 86 102 5 42 82 71 142 99			
109 133 9 25 131 52 18 32 6 138 24 58 61 104 64			

The PLAN Procedure

Factor	Select	Levels	Order
Plot	66	142	Random
35 104 85 50 17 75 60 23 33 28 18 22 81 42 83 134 13 11 16			
117 111 122 121 66 53 26 126 102 59 112 62 73 127 8 64 37 118 131			
9 15 76 106 14 135 4 29 79 49 100 90 43 128 1 30 114 38 82			
119 129 3 105 125 93 12 140 44			

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=1

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=2

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 2a. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 1 and 2. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=3

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=4

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 2b. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 3 and 4. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=5

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=6

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 2c. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 5 and 6. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=7

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=8

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 2d. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 7 and 8. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
 PTPe = Predicted Total Pests
 SampleWeek=9

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
 PTPe = Predicted Total Pests
 SampleWeek=10

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 2e. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 9 and 10. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=14

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=15

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 3a. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 14 and 15. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
 PTPe = Predicted Total Pests
 SampleWeek=16

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
 PTPe = Predicted Total Pests
 SampleWeek=17

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 3b. Fitted response surfaces of predicted total pests in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 16 and 17. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPe = Predicted Total Pests
SampleWeek=18

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 3c. Fitted response surface of predicted total pests in fields with crimson clover as the cover crop. Surface shown is for sampling week 18. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=1

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=2

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 4a. Fitted response surfaces of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 1 and 2. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=3

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=4

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 4b. Fitted response surfaces of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 3 and 4. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=7

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=8

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 4c. Fitted response surfaces

of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 5 and 6. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Figure 4d. Fitted response surfaces of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=9

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=10

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 4e. Fitted response surfaces of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 9 and 10. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
 PTPr = Predicted Total Predators
 SampleWeek=14

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
 PTPr = Predicted Total Predators
 SampleWeek=15

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 5a. Fitted response surfaces of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 14 and 15. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=16

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPr = Predicted Total Predators
SampleWeek=17

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 5b. Fitted response surfaces of predicted total predators in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 16 and 17. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

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Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
 PTP_r = Predicted Total Predators
 SampleWeek=18

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 5c. Fitted response surface of predicted total predators in fields with crimson clover as the cover crop. Surface shown is for sampling week 18. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=1

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=2

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 6a. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 1 and 2. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
 PTPa = Predicted Total Parasitoids
 SampleWeek=3

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
 PTPa = Predicted Total Parasitoids
 SampleWeek=4

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 6b. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 3 and 4. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=5

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=6

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 6c. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 5 and 6. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=7

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=8

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 6d. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 7 and 8. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=9

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cover Crop, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=10

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 6e. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 9 and 10. From data taken from cotton fields during the cover crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=14

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=15

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 7a. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 14 and 15. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=16

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Cover Crop Effect on Numbers of Insects on Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
PTPa = Predicted Total Parasitoids
SampleWeek=17

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 7b. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surfaces shown are for sampling weeks 16 and 17. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Cover Crop Effect on Numbers of Insects in Cotton

SampleTime=Cotton, CoverCrop=Crimson Clover
 PTPa = Predicted Total Parasitoids
 SampleWeek=18

DLR = Distance (ft) Left to Right, DUD = Distance (ft) Up to Down, Up = North

Figure 7c. Fitted response surfaces of predicted total parasitoids in fields with crimson clover as the cover crop. Surface shown is for sampling week 18. From data taken from cotton fields during the cotton crop phase in Tift county, Georgia in 2001.

Table 3. ANOVA for Total Insect Pests during the Cover Crop Phase of the Study involving 20 farms located in Tift County, Georgia in 2001 prior to planting Cotton.

Source of Variation	df	R/F	VC / MS	Z / F	Pr > Z/F
Cover Crop (CC)	3	R	17.1745	1.18	0.1186
DLR(CC)	81	R	0.2143	6.34	0.0001
DUD(CC)	93	R	0.6008	6.81	0.0001
SampleWeek (SW)	7	R	0.0000	---	---
CC*SW	27	R	5.8239	4.12	0.0001
mSW	1	F	2.065e-3	0.01	0.9200
mDLR	1	F	11.3967	55.19	0.0001
mDUD	1	F	3.3721	16.33	0.0001
mSW*mSW	1	F	26.1470	126.62	0.0001
mDLR*mDLR	1	F	1.6892	8.18	0.0042
mDUD*mDUD	1	F	0.01032	0.05	0.8307
mSW*mDLR	1	F	0.0351	0.17	0.6804
mSW*mDUD	1	F	27.6256	133.78	0.0001
mDLR*mDUD	1	F	39.9371	193.40	0.0001
mSW*mDLR*mDUD	1	F	14.7069	71.22	0.0001
Residual	21218	R	0.2065	103.00	0.0001

Notes: R/F denotes Random or Fixed Effects in the Proc MIXED model. VC / MS denotes Variance Component or Mean Square associated with R/F, resp. Z / F denotes the statistical test used, either the Z test (standardized Chi-Square test) or the F-test. DLR denotes the distance in feet left to right (West to East). DUD denotes the distance in feet up or down where up is North. Lower case prefix 'm' on fixed effect lines denotes that for SW, 5.5 was subtracted from each Sample Week (Draper & Smith, 1981) and answer was divided by 2; and for DLR and DUD, distances were determined from center of field in the four cardinal directions and they were divided by 10. Magnitude of numbers were diminished to facilitate ease of computation in Proc MIXED (SAS, 2002). Insect pests include TBW (tobacco bud worm), *Heliothis virescens* (F.), CEW (corn ear worm), *Helicoverpa zea* (Boddie), TPB (tarnished plant bug), *Lygus lineolaris* (Palisot de Beauvois), SGSB (southern green stink bug), *Nezara viridula*, BSB (brown stink bug), *Euschistus servus* (Say), and GSB (green stink bug), *Acrosternum hilare* (Say).

Table 4. ANOVA for Total Insect Pests during the Cotton Phase of the Study involving 20 farms located in Tift County, Georgia in 2001 after Cotton was Planted..

Source of Variation	df	R/F	VC / MS	Z / F	Pr > Z/F
Cover Crop (CC)	4	R	9.9699	0.87	0.1914
DLR(CC)	108	R	0.3707	7.10	0.0001
DUD(CC)	120	R	1.0247	7.62	0.0001
SampleWeek (SW)	2	R	0.0000	---	---
CC*SW	16	R	29.4368	3.00	0.0014
mSW	1	F	19.0671	11.56	0.0007
mDLR	1	F	0.4124	0.25	0.6188
mDUD	1	F	86.1647	52.24	0.0001
mSW*mSW	1	F	6.1358	3.72	0.0539
mDLR*mDLR	1	F	105.3967	63.90	0.0001
mDUD*mDUD	1	F	40.5917	24.61	0.0001
mSW*mDLR	1	F	48.7398	29.55	0.0001
mSW*mDUD	1	F	3464.9935	2100.76	0.0001
mDLR*mDUD	1	F	895.5747	542.97	0.0001
mSW*mDLR*mDUD	1	F	0.1320	0.08	0.7720
Residual	14379	R	1.6494	84.79	0.0001

Notes: R/F denotes Random or Fixed Effects in the Proc MIXED model. VC / MS denotes Variance Component or Mean Square associated with R/F, resp. Z / F denotes the statistical test used, either the Z test (standardized Chi-Square test) or the F-test. DLR denotes the distance in feet left to right (West to East). DUD denotes the distance in feet up or down where up is North. Lower case prefix 'm' on fixed effect lines denotes that for SW, 16 was subtracted from each Sample Week (Draper & Smith, 1981) and answer was divided by 2; and for DLR and DUD, distances were determined from center of field in the four cardinal directions and they were divided by 10. Magnitude of numbers were diminished to facilitate ease of computation in Proc MIXED (SAS, 2002). Insect pests include TBW (tobacco bud worm), *Heliothis virescens* (F.), CEW (corn ear worm), *Helicoverpa zea* (Boddie), TPB (tarnished plant bug), *Lygus lineolaris* (Palisot de Beauvois), SGSB (southern green stink bug), *Nezara viridula*, BSB (brown stink bug), *Euschistus servus* (Say), and GSB (green stink bug), *Acrosternum hilare* (Say).

Table 5. ANOVA for Total Insect Predators during the Cover Crop Phase of the Study involving 20 farms located in Tift County, Georgia in 2001 prior to planting Cotton.

Source of Variation	df	R/F	VC / MS	Z / F	Pr > Z/F
Cover Crop (CC)	3	R	10.3221	1.19	0.1163
DLR(CC)	81	R	0.0134	6.33	0.0001
DUD(CC)	93	R	0.0287	6.80	0.0001
SampleWeek (SW)	7	R	0.0000	---	---
CC*SW	27	R	2.6495	4.12	0.0001
mSW	1	F	0.1128	5.79	0.0161
mDLR	1	F	1.0562	54.22	0.0001
mDUD	1	F	0.3767	19.34	0.0001
mSW*mSW	1	F	0.7724	39.65	0.0001
mDLR*mDLR	1	F	0.0592	3.04	0.0813
mDUD*mDUD	1	F	6.039e-3	0.31	0.5769
mSW*mDLR	1	F	3.3712	173.06	0.0001
mSW*mDUD	1	F	6.0626	311.22	0.0001
mDLR*mDUD	1	F	14.2282	730.40	0.0001
mSW*mDLR*mDUD	1	F	0.1126	5.78	0.0162
Residual	21218	R	0.0195	103.00	0.0001

Notes: R/F denotes Random or Fixed Effects in the Proc MIXED model. VC / MS denotes Variance Component or Mean Square associated with R/F, resp. Z / F denotes the statistical test used, either the Z test (standardized Chi-Square test) or the F-test. DLR denotes the distance in feet left to right (West to East). DUD denotes the distance in feet up or down where up is North. Lower case prefix 'm' on fixed effect lines denotes that for SW, 5.5 was subtracted from each Sample Week (Draper & Smith, 1981) and answer was divided by 2; and for DLR and DUD, distances were determined from center of field in the four cardinal directions and they were divided by 10. Magnitude of numbers were diminished to facilitate ease of computation in Proc MIXED (SAS, 2002). Insect Predators include big-eyed bug, *Geocoris punctipes* (Say); pirate bug, *Orius insidiosus* (Say); red imported fire ant, *Solenopsis invicta* Buren; and these four lady bugs: convergent lady beetle, *Hippodamia convergens* Guerin-Meneville; seven-spotted lady beetle, *Coccinella septempunctata* L.; ladybird beetle, *Coleomegilla maculata* (DeGeer); and multicolored Asian lady beetle, *Harmonia axyridis* (Pallas).

Table 6. ANOVA for Total Insect Predators during the Cotton Phase of the Study involving 20 farms located in Tift County, Georgia in 2001 after Cotton was Planted..

Source of Variation	df	R/F	VC / MS	Z / F	Pr > Z/F
Cover Crop (CC)	4	R	2.1038	1.27	0.1012
DLR(CC)	108	R	0.0769	7.32	0.0001
DUD(CC)	120	R	0.0417	7.69	0.0001
SampleWeek (SW)	2	R	0.0000	---	---
CC*SW	16	R	1.1146	3.00	0.0014
mSW	1	F	0.3712	11.12	0.0009
mDLR	1	F	0.0407	1.22	0.2695
mDUD	1	F	0.8108	24.29	0.0001
mSW*mSW	1	F	0.0110	0.30	0.5826
mDLR*mDLR	1	F	0.1198	3.59	0.0583
mDUD*mDUD	1	F	0.0664	1.99	0.1579
mSW*mDLR	1	F	121.8650	3650.84	0.0001
mSW*mDUD	1	F	20.5948	616.98	0.0001
mDLR*mDUD	1	F	44.4094	1330.42	0.0001
mSW*mDLR*mDUD	1	F	0.0174	0.52	0.4723
Residual	14379	R	0.0334	84.79	0.0001

Notes: R/F denotes Random or Fixed Effects in the Proc MIXED model. VC / MS denotes Variance Component or Mean Square associated with R/F, resp. Z / F denotes the statistical test used, either the Z test (standardized Chi-Square test) or the F-test. DLR denotes the distance in feet left to right (West to East). DUD denotes the distance in feet up or down where up is North. Lower case prefix 'm' on fixed effect lines denotes that for SW, 16 was subtracted from each Sample Week (Draper & Smith, 1981) and answer was divided by 2; and for DLR and DUD, distances were determined from center of field in the four cardinal directions and they were divided by 10. Magnitude of numbers were diminished to facilitate ease of computation in Proc MIXED (SAS, 2002). Insect Predators include big-eyed bug, *Geocoris punctipes* (Say); pirate bug, *Orius insidiosus* (Say); red imported fire ant, *Solenopsis invicta* Buren; and these four lady bugs: convergent lady beetle, *Hippodamia convergens* Guerin-Meneville; seven-spotted lady beetle, *Coccinella septempunctata* L.; ladybird beetle, *Coleomegilla maculata* (DeGeer); and multicolored Asian lady beetle, *Harmonia axyridis* (Pallas).

Table 7. ANOVA for Total Insect Parasitoids during the Cover Crop Phase of the Study involving 20 farms located in Tift County, Georgia in 2001 prior to planting Cotton.

Source of Variation	df	R/F	VC / MS	Z / F	Pr > Z/F
Cover Crop (CC)	3	R	0.0691	1.19	0.1172
DLR(CC)	81	R	1.958e-3	6.33	0.0001
DUD(CC)	93	R	7.82e-4	6.70	0.0001
SampleWeek (SW)	7	R	0.0000	---	---
CC*SW	27	R	0.0194	4.12	0.0001
mSW	1	F	4.634e-3	1.61	0.2042
mDLR	1	F	0.1553	53.96	0.0001
mDUD	1	F	8.92e-4	0.31	0.5801
mSW*mSW	1	F	0.3408	118.4	0.0001
mDLR*mDLR	1	F	0.0355	12.32	0.0004
mDUD*mDUD	1	F	0.0521	18.09	0.0001
mSW*mDLR	1	F	4.2441	1474.66	0.0001
mSW*mDUD	1	F	0.1837	63.82	0.0001
mDLR*mDUD	1	F	4.6388	1611.81	0.0001
mSW*mDLR*mDUD	1	F	0.0482	16.73	0.0001
Residual	21218	R	2.878e-3	103.00	0.0001

Notes: R/F denotes Random or Fixed Effects in the Proc MIXED model. VC / MS denotes Variance Component or Mean Square associated with R/F, resp. Z / F denotes the statistical test used, either the Z test (standardized Chi-Square test) or the F-test. DLR denotes the distance in feet left to right (West to East). DUD denotes the distance in feet up or down where up is North. Lower case prefix 'm' on fixed effect lines denotes that for SW, 5.5 was subtracted from each Sample Week (Draper & Smith, 1981) and answer was divided by 2; and for DLR and DUD, distances were determined from center of field in the four cardinal directions and they were divided by 10. Magnitude of numbers were diminished to facilitate ease of computation in Proc MIXED (SAS, 2002). Evidence of parasitization was determined by examining those insect pests found to see if they had a puncture mark on their bodies.

Table 8. ANOVA for Total Insect Parasitoids during the Cotton Phase of the Study involving 20 farms located in Tift County, Georgia in 2001 after Cotton was Planted..

Source of Variation	df	R/F	VC / MS	Z / F	Pr > Z/F
Cover Crop (CC)	4	R	0.9289	1.40	0.0802
DLR(CC)	108	R	0.0442	7.34	0.0001
DUD(CC)	120	R	0.0223	7.73	0.0001
SampleWeek (SW)	2	R	0.0000	---	---
CC*SW	16	R	0.0218	3.00	0.0014
mSW	1	F	8.27e-4	0.18	0.6692
mDLR	1	F	0.0345	7.50	0.0062
mDUD	1	F	9.689e-3	2.11	0.1465
mSW*mSW	1	F	9.414e-3	2.05	0.1522
mDLR*mDLR	1	F	0.2341	50.98	0.0001
mDUD*mDUD	1	F	0.3235	70.44	0.0001
mSW*mDLR	1	F	16.7708	3652.18	0.0001
mSW*mDUD	1	F	0.9253	201.49	0.0001
mDLR*mDUD	1	F	28.7616	6263.42	0.0001
mSW*mDLR*mDUD	1	F	0.0468	10.19	0.0014
Residual	14379	R	4.592e-3	84.79	0.0001

Notes: R/F denotes Random or Fixed Effects in the Proc MIXED model. VC / MS denotes Variance Component or Mean Square associated with R/F, resp. Z / F denotes the statistical test used, either the Z test (standardized Chi-Square test) or the F-test. DLR denotes the distance in feet left to right (West to East). DUD denotes the distance in feet up or down where up is North. Lower case prefix 'm' on fixed effect lines denotes that for SW, 16 was subtracted from each Sample Week (Draper & Smith, 1981) and answer was divided by 2; and for DLR and DUD, distances were determined from center of field in the four cardinal directions and they were divided by 10. Magnitude of numbers were diminished to facilitate ease of computation in Proc MIXED (SAS, 2002). Evidence of parasitization was determined by examining those insect pests found to see if they had a puncture mark on their bodies.